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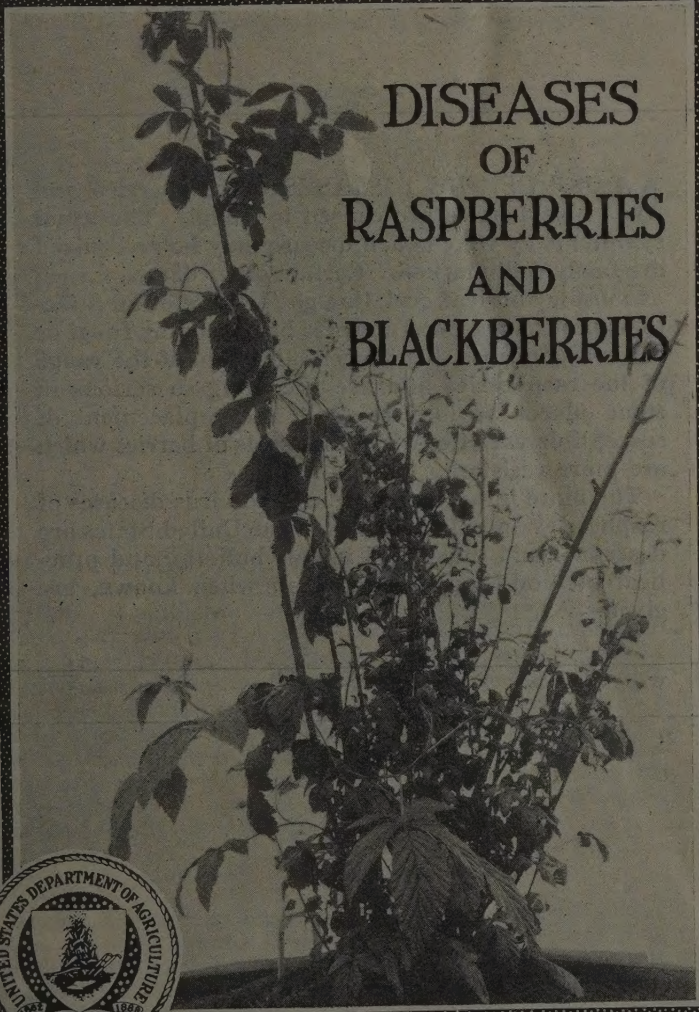

DISEASES OF RASPBERRIES AND BLACKBERRIES

MOST OF THE DISEASES of raspberries and blackberries are caused by fungi. The usual symptoms by which each disease may be recognized are fairly well marked. Certain other diseases, such as mosaic and leaf curl, though they are of an infectious nature, are not known to be caused by fungi or other organisms. They occur throughout the range of the raspberries and are becoming so serious in some places as to necessitate the replacement of susceptible varieties with other sorts of berries which are more resistant.

The more important fungous and virus diseases of raspberries and blackberries of the United States are described and illustrated in this bulletin, and practical methods for their control, when known, are given.

WASHINGTON, D. C. Issued June, 1926

DISEASES OF RASPBERRIES AND BLACKBERRIES

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INTRODUCTION

RASPBERRIES, blackberries, and their relatives, representing different species of the genus Rubus, differ as to their habits of growth. On this account alone their horticultural varieties might differ widely with regard to their susceptibility to a particular disease. These berries are grown as garden crops throughout the United States and commercially in many favorable localities. It is clear that methods worked out for controlling a disease of raspberries in Michigan would not necessarily prove satisfactory in controlling the same disease on dewberries as grown in Georgia. It is proposed to discuss the diseases of raspberries and blackberries separately, although in some cases their horticultural varieties may all be subject to certain of the diseases to be considered.

MOSAIC AND RELATED DISEASES

Among the most serious diseases of raspberries are those belonging to the virus group. This includes mosaic and leaf curl, which were formerly confused under the term "yellows," and streak, which is confined to black and purple raspberries. These diseases have certain characteristics in common. An infected bush never recovers. If one part of a plant is attacked, the whole bush—leaves, canes, and

roots—will eventually suffer from the malady. All stock propagated from such plants, either by rooting of the tips of canes or as suckers from the roots, is likewise affected. The general effect of any one of the diseases is a sharp reduction in the growth of the plants and in the yield of fruit.

MOSAIC ON RED RASPBERRIES

Mosaic is found throughout the range of the red raspberry. A group of diseased plants is noticeable because of the shorter canes, the sparse yellowish foliage, and the thin growth. Mosaic causes progressive stunting, the new growth from diseased plants being shorter than that of the year previous, and the leaves are dwarfed,

FIG. 1.—Mosaic of red raspberry, showing green blisters on leaves of suckers late in spring

mottled, and sometimes deformed. Fruit from a thoroughly infected bush is usually worthless, being dry and seedy or tasteless.

The character of the foliage on young suckers furnishes the most constant symptoms of mosaic. Late in the spring the leaves begin to show large irregular green blisters which arch upward. The tissue around the blisters is yellowish (fig. 1). The leaves put out during very hot weather either do not show the mosaic discoloration or show it faintly as a definite pattern or as a flecking of yellow in the dark green. In late summer the leaves near the tip of the sucker show a fine, yellowish, speckled mottling (fig. 2). The leaves on the fruiting canes are smaller than normal and on most varieties show large green blisters and yellowish speckling.

MOSAIC ON BLACK RASPBERRIES

Mosaic is widespread and serious on black raspberries. Grouped under this name there appear to be at least three types of disease, each of which can be transmitted from one plant to another in the usual way. One is a comparatively mild form which shows itself chiefly by a uniform speckling of the young leaves with light and dark green. This appears in the spring, and the leaves formed then continue to have the mottling throughout the season, but those formed after the advent of hot weather appear normal; then, with the return of cool weather in the late summer, the speckling appears at the tips of shoots. This type of mosaic is gradual in its action, both as to the dwarfing of the plants and the reduction of the crop, but it shortens the life of the plantation as a whole. Because of its slow progress and the masking effect of hot weather, it is not easy to detect. Canes of plants affected with this mild mosaic root readily at the tips.

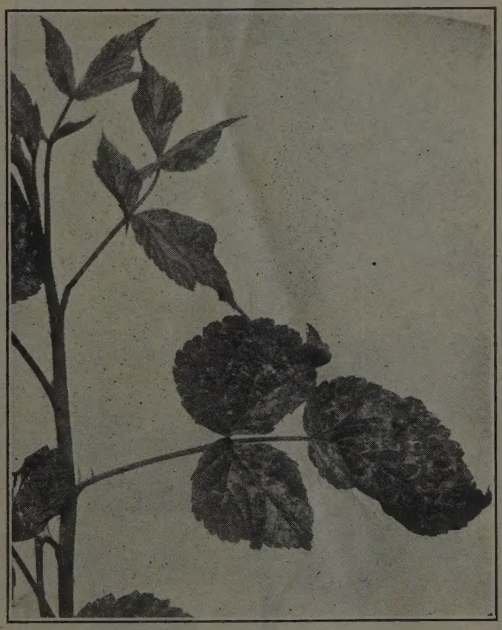

FIG. 2.—Mosaic of red raspberry, showing speckled mottling of tip leaves of suckers late in summer

In the second form of the disease the leaves become light yellowish green in color, small, and with their margins turned upward. Infected bushes are severely stunted and short lived, and the fruit is worthless.

The third type of mosaic on blackcaps is that produced by inoculation with the virus from a diseased red raspberry, but it does not present the same symptoms as on the latter host. The tips of the young shoots are either killed for a short distance or their terminal growth practically stops, and the petioles of tip leaves as well as the stem itself near the end are discolored. Often a rosette of small, stunted branches occurs. The leaves are small and usually mottled. Fewer young canes are produced than on a normal plant, and the bush is either killed or rendered completely worthless. Canes of affected plants do not usually root at the tips.

Unfavorable weather conditions, especially late spring frosts, sometimes produce on the leaves of the fruiting canes a mottling which closely resembles mosaic. In this case, however, the leaves of

young canes usually appear normal. Environmental conditions may also cause the fruit to be imperfect or dry and seedy, but this condition will not persist from year to year.

The means by which mosaic is spread and the methods recommended for its control are discussed on pages 8 to 11.

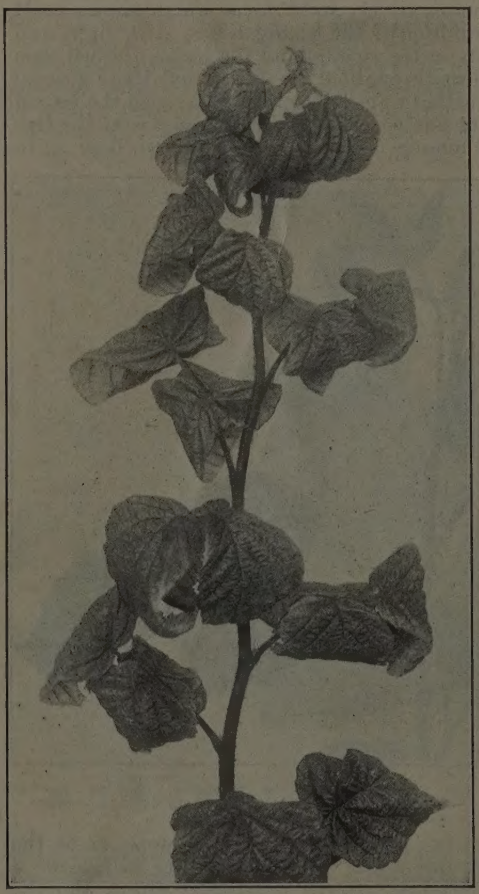

FIG. 3.—Leaf curl of red raspberry

LEAF CURL ON RED RASPBERRIES

Leaf curl is not common in New York and New England, but it does some damage in Ontario, and in many localities from Ohio westward it is more prevalent and serious than mosaic on Cuthbert, the variety chiefly grown. It is easier to eradicate than mosaic because its symptoms are more conspicuous.

The first sign of this disease is usually manifested at the tip of a vigorously growing cane. The leaflets in this region appear rounded, with their margins curled downward. This condition does not spread during the same season to other canes in the hill already above the ground, but all canes growing up later will be similarly affected. The following spring both the old canes and the young shoots will have their leaves conspicuously curled and dwarfed, and the young shoots will be shorter than normal (fig. 3). Each year the plant becomes less vigorous, and the new shoots are shorter, until finally they are only a few inches in height. After a cane shows curled leaves its fruit is valueless for market purposes; ripening prematurely it is small, dry, seedy, and unpleasant to the taste.

When diseased shoots first show above the ground they are pale yellowish green in color but soon darken, and at maturity their

leaves are generally darker than normal. During the summer the leaf spaces between the veins are often light green, but later they may become reddish brown in color. This is most noticeable on the shoots which appear in late summer. In general, the mottling of leaf curl can be distinguished from that of mosaic by the fact that in mosaic the veins and adjoining tissues are light green with darker green spots between, whereas with leaf curl the reverse is true.

LEAF CURL ON BLACK RASPBERRIES

Leaf curl of black raspberries, though not common, occurs locally in a number of districts and is disastrous in many fields in which it obtains a foothold. It resembles leaf curl on the red varieties.

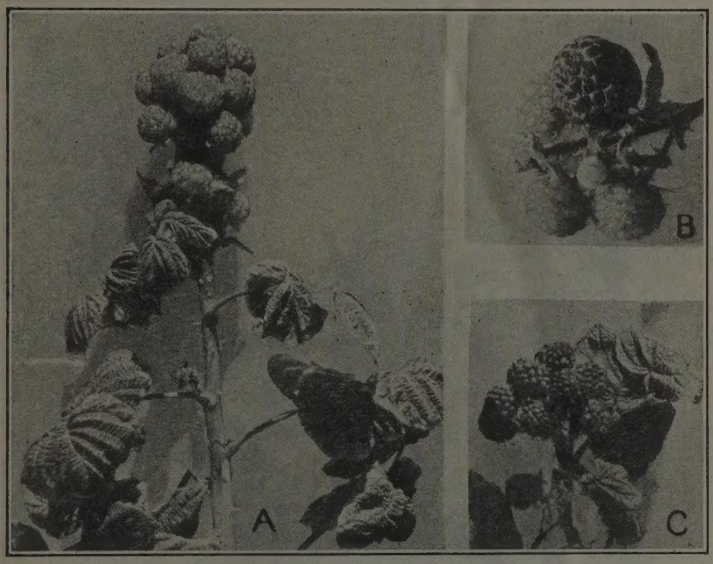

FIG. 4.—Leaf curl on fruiting canes of black raspberry; *A*, dwarfed leaves with sunken veins; *B*, fruit from a healthy cane; *C*, mummied fruit on a diseased cane

The most conspicuous symptoms are found on the tip leaves, which are arched upward as if by contraction of the margins (fig. 4). The veins are sunken, with the intervening tissue ridged or arched upward. The leaves become firm and rigid in appearance and remain small and nearly circular in outline. The veins are usually darker in color than the tissues between. The symptoms appear first on a single cane. The following year all canes are affected, the plant is bushy and much dwarfed, and its berries are small, dry, and worthless. The young canes are stiff and brittle and frequently do not branch; they are shorter each year, until finally the plant dies. During the first season following infection the canes occasionally root at the tips; in later stages they are short and stiff and will not

bend to the ground. See pages 8 to 11 for a discussion of methods of dissemination and control.

STREAK

Streak (eastern blue-stem, rosette) is a virus disease of black raspberries. It has been found on certain purple sorts but has not been recognized on red varieties. It is the limiting factor in raspberry growing in a number of sections.

The leaf symptoms of streak are first apparent soon after blossoming time. The tip leaves of young canes show a peculiar curling. The midrib of the leaf is at first sharply hooked or recurved and later curled downward and backward, sometimes rolling the

FIG. 5.—Streak of black raspberry, showing leaf symptoms. The midribs are hooked or recurved

leaflet into a cylinder. The curling is most severe on the younger leaves of rapidly growing parts (fig. 5). The margins of the leaflets are not curled downward, as in leaf curl, nor are the veins depressed. On plants which have been infected for a year or more the canes are shortened and the leaves close together, in extreme cases giving the appearance of a rosette (fig. 6). By midsummer the leaves of diseased plants, especially those of the fruiting canes, show an indefinite mottling, the light and dark areas not being so well defined as in mosaic. The dark areas are not arched upward.

The characteristic from which the name "streak" is obtained is an irregular discoloration of the young canes (fig. 7). Dots and irregular vertical stripes of dark blue, as though made with a coarse blue pencil, appear in June and July on the young shoots, especially

those near the ground. They affect only the outer normally green layer of the cane and do not extend into the wood or pith. This discoloration of the canes does not always appear.

Broad, deep, continuous streaks of blue or black, extending from the ground up one side of the cane, sometimes even to the tip, are not characteristic of streak, but usually accompany blue stem (wilt), a fungous disease described on page 18.

FIG. 6.—Streak of black raspberry in the rosette stage: *A*, diseased plant; *B*, normal plant

If a young plant has streak when set in the field it can be recognized as weak and sickly in the fall, and by August or September the tips of the upper leaves are recurved or curled. Bushes infected after they are planted show the first symptoms of curled leaves in a few weeks. If the infection occurred early in the season the canes will usually show a few blue dots or streaks before the wood ripens in late summer. The next year the leaves of all young shoots and laterals will be curled, the canes stunted, and the fruit small and inferior. Frequently the canes do not survive the second winter after

infection. Infected canes may root at the tips until the disease reaches a late stage. In neglected plantings the symptoms of streak are less conspicuous than in well-cultivated fields.

MEANS OF DISSEMINATION OF VIRUS DISEASES

Mosaic, leaf curl, and streak of raspberries are similar in their nature and in their means of transmission from plant to plant. No parasitic organism has been found to be the cause of these diseases, nor are they brought about by unfavorable weather, soil, or fertility conditions, although the environment may aggravate or obscure their

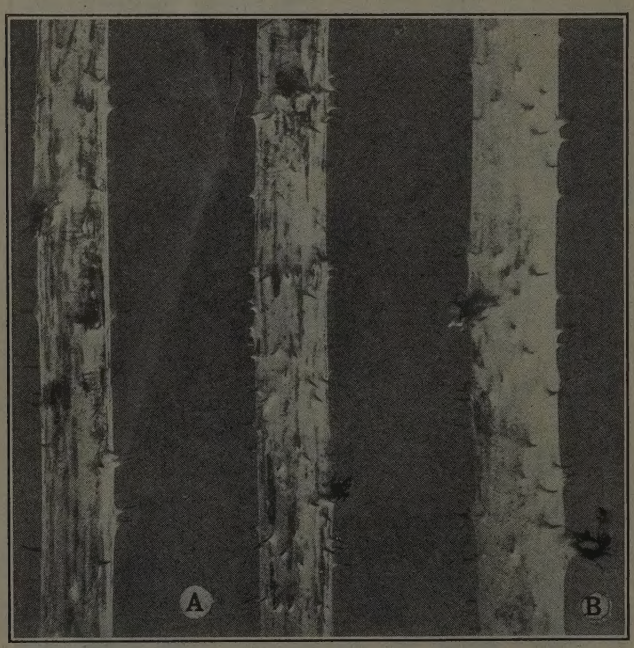

FIG. 7.—Black-raspberry canes: *A*, showing streak symptoms; *B*, normal cane

symptoms. The juices of diseased plants contain substances which, if properly introduced into a healthy plant, will reproduce the disease. This infective material is sometimes termed "virus."

NURSERY STOCK

Probably these diseases are most frequently introduced into new localities by nursery stock, since they are transmitted to the vegetative offspring of affected plants. In the case of black raspberries the rooted tips and in the red sorts the suckers from the roots will carry the diseases. These young plants, which are used for propagation, are dug and packed for shipment while dormant. In this

condition, since there are no leaves, it is not possible to detect diseased plants.

INSECTS

Diseases of the mosaic type are found on many crop plants, and in a number of cases it has been demonstrated that the infection may be carried from diseased to healthy plants by insects. On some of these plants, tobacco for example, the disease may be carried by merely brushing against the leaves of a diseased plant and then against a healthy one; or the disease may be induced in a healthy plant by injecting into it some juice pressed out of a diseased plant. So far, mechanical means, such as injecting with a needle or bruising, have not been successfully used to transfer raspberry mosaic, leaf curl, or streak.

It has been found, however, that raspberry aphids (plant-lice) of at least two genera [1] spread these diseases. If these aphids feed on the leaves of an infected plant and then move to a healthy bush they usually carry with them some of the virus, inject it into the tissues when they again insert their setæ, and so introduce the disease into the new bush. These aphids carry the infectious virus of mosaic, leaf curl, and streak from plant to plant in the field.

CONTROL

SECURE CLEAN NURSERY STOCK

It is most important that plants be obtained from fields or localities free from mosaic, leaf curl, and streak, or from districts where systematic efforts have been made to produce clean nursery stock. It is, of course, useless to go to the trouble and expense of getting healthy stock and then planting it near diseased bushes. The farther from diseased plants the clean nursery stock is set the better the chances for its remaining healthy. Where healthy plants are to be grown for sale the plantings should be at least 20 rods from outside sources of infection. Where the planting is only for the purpose of fruit production, the distance need not be so great.

VARIETAL RESISTANCE

Reports as to the degree of resistance to these virus diseases shown by different varieties of raspberries in various parts of the country are so contradictory that no general statement can be made with regard to the susceptibility of particular varieties. Perhaps the wisest policy would be for each grower to select for planting those varieties which have proved to be most resistant in his locality.

INSECT CONTROL

It might seem that the spread of these diseases could be prevented by controlling the aphid carriers. Aphids may be largely controlled by nicotine in the form of either dust or spray (see Farmers' Bulletin No. 1371, entitled Diseases and Insects of Garden Vegetables), and this treatment may be used where they are very abundant.

[1] *Aphis rubiphila* Patch and *Amphorophora rubi* Kalt.

Under conditions of moderate infection, however, it is not certain that treatment for the control of aphids will result in any material slowing up of the spread of the disease, since not all of the aphids can be killed by any known method, and those remaining will still act as carriers.

ROGUING

If the planting has been set out with certified nursery stock, the chief method of preventing the further spread of these virus diseases recommended at present is roguing, that is, inspection of the plantings and destruction of diseased plants. Roguing as a means of control of mosaic of red raspberries is not advised in a planting over 2 years old where the proportion of mosaic is over 5 per cent. Having secured certified stock and planted it in a location sufficiently removed from outside sources of infection, such as wild raspberries and infected fields, the grower should have his plantings examined at least twice during the growing season by a reliable inspector and the condemned plants marked. The last inspection should be made some time in September, or at least after the passing of the hot-weather period, as the symptoms of mosaic are obscured on growth made in hot weather. Leaf curl and streak can be detected equally well during hot or cool weather. As soon as practicable after each inspection the diseased plants should be carefully dug and burned. This will prevent any aphids moving from them to healthy plants. If young canes are merely broken over, the plants to be removed at leisure, aphids feeding on these canes will pass to other plants as soon as the leaves begin to wilt. It should be remembered also that where the diseased plants on which the aphids are feeding are roughly handled in digging or assembling for burning, some of the aphids will be knocked off on the ground or on other plants. Thus, the disease may be spread more rapidly in attempting to control it by roguing than would have been the case if the affected plants had not been disturbed.

In taking out diseased red raspberries, it is important to remove all connecting roots; otherwise new shoots from remaining roots will spring up and, being diseased, will serve as a source of further infection. Remove all canes and roots within 3 feet of an infected plant. The removal of one apparently healthy plant on each side of the affected plants may not be necessary in the first inspection of a new planting from certified stock. Effective roguing of blackcaps is somewhat easier than that of red varieties, because no suckers spring from the roots if plants are taken out with reasonable care. Diseased plants should never be cut off at the surface of the ground but should be dug up. Thorough and repeated inspection, followed by prompt destruction of diseased plants in such a way as to avoid scattering the aphids, has been found to be fairly effective in controlling these diseases on varieties which are not very susceptible and which show the symptoms of the disease clearly enough to enable one to detect its presence sufficiently early.

It is highly important in the control of mosaic to detect the disease in its earliest stages if the results to be obtained from roguing are to be satisfactory. There should also be community action and local cooperation. The methods recommended to the grower should be

applied even more carefully by those propagating plants for distribution or sale. The practice of obtaining stock for new plantings from one's neighbors simply because they are handy and inexpensive should be discouraged. Only certified stock or that which is known to be healthy should be used for new plantings.

FUNGOUS DISEASES OF RASPBERRIES

ANTHRACNOSE[2]

Anthracnose has been found to be one of the most destructive fungous diseases of black raspberries wherever grown.

SYMPTOMS ON THE CANES

The symptoms of the disease are manifested most strikingly on the canes, which are frequently found spotted with light grayish areas an eighth of an inch or more in diameter (fig. 8). On young shoots the disease first appears as very small circular slightly sunken spots. As the disease progresses the spots enlarge and become pale buff or ash gray at the center, while the margin is somewhat raised and purple in color. The older lesions extend down into the cambium and sap-conducting tissues. As the infected canes dry out they may crack up and down for an inch or two. In some cases the canes present a rough warted or knotted appearance because of the swelling of tissue beneath the bark in the regions affected by the fungus. The parasite first infects the young tip ends of canes and branches and works in the living tissue of the bark, causing the death of those cells vitally concerned with growth and sap flow. Where canes show numbers of cankers they will be partly girdled,

FIG. 8.—Anthracnose of raspberry: *A*, on a sucker of a purple raspberry; *B*, on an older cane of a black raspberry

[2] Caused by *Plectodiscella veneta* (Speg.) Burk.

so that the fruit fails to develop to its normal size, often shriveling and drying up on the vines. A late infection may occur on the lateral branches, stunting them and preventing proper growth and bud formation for the next season.

SYMPTOMS ON THE LEAVES

Anthracnose sometimes attacks the leaves. The irregular spots, at first very small, may become a sixteenth of an inch in diameter. They have a light-gray center and a purple margin. The diseased tissue frequently drops out, so that there is left a "shot-hole" effect. The leafstalks are also subject to attack. Certain spots on the leaves caused by an entirely different fungus are often mistaken for anthracnose. The remedies for their control are much the same, however. (See fig. 18, showing anthracnose and leaf spot on dewberry leaves.)

SYMPTOMS ON THE FRUIT

When the branches bearing the berry clusters are badly infected the fruit fails to mature properly, ripening without pulp, so that it becomes dry and hard. The fungus may also attack the drupelets of the berry, causing them to become rusty brown and scabby.

HOW THE DISEASE IS SPREAD

The fungus causing the anthracnose condition attacks plant parts locally, spreading out from the original point of infection only slightly. In about a week small purple spots begin to appear. With the death of the cells at the center of a spot this part turns ash gray, and minute fruiting bodies are formed which consist of vast numbers of spore-bearing hyphæ packed together. The conidia, or spores, which are produced here gather in a heap and are set free and dispersed by drops of dew or rain. This is repeated over and over again during the growing season, so that the disease is widely spread to new plants by means of the spores.

The fungus lives over winter in the canes and gradually matures not only a new crop of spores in the spring but also an overwintering stage which forms the ascospores for starting new infections.

SUSCEPTIBLE VARIETIES

Most varieties of black raspberries are very susceptible. The Quillen is said to be resistant. The canes of the Columbian and Royal Purple varieties are readily infected. The red raspberries, such as the Cuthbert, Ranere (*St. Regis*), and Turner, usually are not injured. It is reported, however, that in Wisconsin the fruitstalks of the Miller and King are likely to be so badly infected as to cause the fruit to dry up.

TREATMENT

New plantings.—A new planting should be set out with disease-free nursery stock. The mycelium of the anthracnose fungus can live over winter in the old cane parts, and the stubs of old canes usually left attached to black-raspberry tip plants may become a

source of new infection. For this reason the part remaining above the ground after planting should be removed and burned. Tip plants obtained from the grower's own field should be planted while dormant. If left in the spring until the young shoots are over 6 or 8 inches high, they would be very susceptible to infection should anthracnose be present in the old field. Do not plant on low ground or in pockets.

Pruning.—All fruiting canes should be cut out and burned after harvest. New canes which appear to be badly infected at this time should also be destroyed.

Cultivation.—Thorough cultivation should be given the crop, to insure that the rows are kept free from weeds and rubbish, which tend to maintain moisture among the canes. The spores by which the disease is propagated are set free by the dew or rain and may be carried from plant to plant by insects, or in case of a driving rain the spores may be blown some distance. On this account wild brambles in near-by fence rows and hedges should be burned so far as practicable.

Spraying.—Raspberry leaves are very susceptible to injury by the ordinary fungicides. In certain experiments conducted by the department, when either lime-sulphur or Bordeaux mixture was applied to the leaves, especially after they had matured and the plants were in vigorous growth, more damage was done by the fungicide, as shown by the quantity of fruit harvested, than was being done by the fungous disease. However, experiments carried on in Wisconsin would indicate that when the sprays are applied not later than a week before the blossoms open, the leaves are not noticeably injured. The leaves on the new shoots especially show little, if any, injury. In case the treatment previously suggested has not proved sufficiently effective, the following spray schedule is recommended:

(1) Lime-sulphur 1 to 10 or Bordeaux mixture 4-4-50 (with calcium caseinate 1 pound to 100 gallons, or a gelatin sticker), applied as a delayed dormant spray or when the leaves just begin to show green.

(2) In the most serious cases a second application of Bordeaux mixture may be advisable. The plants should then be sprayed not later than a week before the blossoms open. Only the young canes should be sprayed, care being taken to avoid spraying the foliage of old canes. Lime-sulphur solution 1 to 40 may be used instead of Bordeaux mixture.

Bordeaux mixture is more liable to produce spray injury in wet weather, whereas lime-sulphur produces more injury to the leaves in hot, dry, sunny weather.

CROWN GALL[3]

Crown gall, a bacterial disease of raspberries and blackberries, is of great economic importance.

SYMPTOMS

Tuberculate, irregular warty swellings up to an inch or more in diameter develop at the base of the canes or at the crown. In such cases the real cause of the death of the plant may escape detection. Numerous galls may also develop on the canes some distance above the ground. (See fig. 13, p. 22, for an illustration

[3] Caused by *Bacterium tumefaciens* E. F. S. and Town.

of crown gall on the blackberry.) In the advanced stages of the disease the flow of sap is interfered with, and the infected plants which do not die have little value. Crown gall is especially severe on raspberries grown on the lighter soils.

The organism, which is very generally distributed in the soil of this country, gains entrance into the living tissues through wounds made by insects or by mechanical injuries, such as the whipping of canes against each other or by the bruising of the crown and other parts during cultivation.

TREATMENT

The planting of nursery stock as free from the disease as possible is the first essential. Plants showing the characteristic galls should be dug up and destroyed. Avoid putting new plants in the place once occupied by a badly diseased one. If a field is found to be thoroughly infected, so that control measures are impracticable, fair yields of fruit can sometimes be obtained for a few seasons by liberal applications of nitrogenous fertilizers and by practicing high culture or thorough cultivation. It is advisable to allow several years to intervene between raspberry plantings on the same site.

CANE BLIGHT[4]

Growers are coming to realize that some of their berry troubles which they formerly thought were caused by the cane-blight fungus are really due to some other malady. Mosaic may cause the death of plants. Discolored patches on the stem may be caused by other fungi. Cane blight is, however, a serious fungous disease and one that has not been readily controlled.

SYMPTOMS

The whole cane or single branches suddenly begin to wilt and die. Infected parts of the bark are lighter colored and are likely to have smutty patches due to masses of the fungous spores extruded on the surface. The wood is strongly colored and very brittle where diseased, so that the cane is easily broken. If the point of attack is near the ground the whole cane dies, but if near the top only the part affected dies. As soon as the diseased area of the bark encircles the cane, the leaves wilt.

The fungus enters the bark through some wound made either by insects or by mechanical injury. Where canes are headed back, the fungus often enters the wound and works down, killing one branch after the other. Warm, wet seasons favor the growth of the fungus, but the loss in fruit may not show until the next year, because the new canes are not usually killed the first season.

The Cuthbert and Marlboro are very susceptible varieties. The Ohio, Gregg, and Kansas are also liable to much injury. The Columbian is said to be fairly resistant.

TREATMENT

Cut out canes showing much of the disease and practice clean cultivation. (See p. 19.) Because of the sporadic appearance of

[4] Caused by *Leptosphaeria coniothyrium* (Fckl.) Sacc.

this disease and the liability to spray injury, spraying black raspberries for the control of cane blight has not been recommended.

ORANGE RUST [5]

The black and the purple raspberry varieties are subject to a perennial constitutional fungous disease called orange rust. Red raspberries are rarely, if ever, infected systemically with this rust.

SYMPTOMS

If the tip plants are infected when received from the nursery, the new shoots that grow up will be weak and spindling, and their leaves will be rather small and pale yellowish green. Within two or three weeks their leaves will be covered on the under side with blisterlike pustules, from which masses of reddish orange spores are being shed (fig. 9). The young canes may appear to "grow out" of the rust toward the end of June, since the upper leaves then bear no rust. The canes are thoroughly infected, however, and they will not blossom the next year. Most of the leaves will show the rust each spring as long as the plant lives. Such infected plants never blossom. (See fig. 16, which shows the effect of this rust on blackberry.)

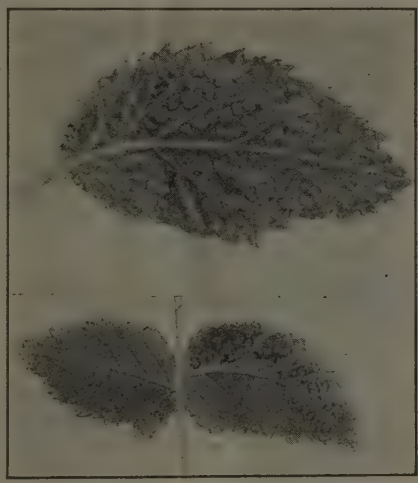

FIG. 9.—Orange rust on blackberry leaves

One sometimes finds old hills in which only a few of the canes show rusted leaves in the spring, whereas the other canes blossom and bear fruit normally. This means that the fungus gained entrance into the crown at least a year after it was planted.

TIME OF INFECTION

The fungus causing the rust has two spore stages. The orange-rust spores which fall upon the leaves of raspberries in May or June infect these leaves locally or only over small areas, so that in August and September they show little brown spots on the under side. The spores (teleutospores) borne in these brown spots are the mature or last spore forms and are very important in the life history and dissemination of the disease. They are the spores that lead to the infection of the buds on the tips of canes which are just becoming rooted. The first signs of the infection leading to the orange-rust stage show the next spring, when the tip plants begin to grow.

If buds or new shoots are being formed from the crowns of old plants in late summer they, too, may become infected constitution-

[5] Caused by *Gymnoconia interstitialis* (Schl.) Lagh.

ally, that is, throughout the whole plant, at this time of year. The fungus then grows down into the crown at the base of this shoot and enters newly formed roots. In this way a few canes in an old hill will show rust the following year.

TREATMENT

Start the new planting with rust-free stock. If the new shoots from tip plants show rusted leaves during the season they are set out, these plants were infected when received from the nursery or when dug from an old raspberry field. Such infected plants never recover from the rust and are useless as fruit bearers. They should be dug and burned as soon as the rust appears. A superficial inspection of nursery stock for orange rust is worthless, because a microscopic examination of the inner tissues of the roots and crown is usually necessary in order to determine whether or not they are infected.

In case an old hill shows a cane or two whose leaves are rusted, while other canes blossom normally, cut out that part of the crown bearing the infected cane or canes and burn them. In this way it is sometimes possible to save the plant. Infected wild brambles in near-by hedge rows ought to be cut down and burned. The operation of cutting and burning rusted plants should be done just as soon as the greenish yellow leaves show signs of rust; otherwise the handling of canes whose leaves are shedding spores merely serves to spread the rust to new plants.

LATE RASPBERRY RUST[6]

The late rust, which has been known to infect wild red raspberries as well as the purple varieties, though not commonly a serious disease, appears occasionally in an epidemic form, attacking the leaves so as to cause premature defoliation in August. In some cases the berries are infected and the canes are so split with the lesions that they fail to live through the winter.

The rust appears sometime in July or August. The pustules breaking out on the under side of the leaves are minute and golden yellowish in color. The spores are rather dry and powdery. Where the canes are infected the living bark dries out a little later and eventually cracks open. It is presumed that there is another stage of the rust which overwinters on hemlock or some species of fir.

This rust is often mistaken for orange rust, and consequently many good raspberry plants have been unnecessarily destroyed. As this late rust is not a constitutional disease, such treatment is without value. No practical method of control has been worked out. See page 19 for suggestions for clean cultivation.

YELLOW LEAF RUST[7]

Another disease often mistaken for orange rust is a leaf rust found on both red and black raspberries. The pustules are yellow, small, and inconspicuous as compared with the bright-orange showy pustules of orange rust, which seldom, if ever, occurs on red rasp-

[6] Caused by *Pucoiniastrum americanum* (Farl.) Arth.
[7] Caused by *Phragmidium imitans* Arthur.

berry. Certain varieties, such as the Cuthbert and Antwerp, have been so seriously infected as to cause the leaves to fall off in great numbers. Hundreds of separate infections may appear on a single leaf. The surface of the leaf is badly ruptured, and the vitality is thus greatly reduced. The winter stage of this rust also occurs on the leaves. These spore clusters are dark chocolate brown. No practical method of control has been suggested except to practice clean cultivation, which will help to keep down the disease.

MILDEW [8]

Under rather moist weather conditions raspberry leaves may become covered with a delicate snow-white powdery mildew. This fungus attacks only the cells in the epidermis of the leaves and ordinarily does but little damage. The mildew, however, may be so abundant as to produce a smothering effect, which is very detrimental.

SPUR BLIGHT [9]

In Colorado, spur blight has been known at times to reduce greatly the yield of red raspberries. Recently it has been reported to be serious in certain localities in Eastern and Middle-Western States.

FIG. 10.—Spur blight of red raspberry. (From Sackett)

SYMPTOMS

During July small chocolate-brown spots begin to appear on the leafstalks and on the epidermis of young canes at the nodes or where the leaves are attached. The region around the bud turns brown, the bud shrivels, and it may die. If the bud lives over winter, it produces only small yellowish leaves but no spur. The leaf blades fall off, leaving the bare brown stalks on the canes. Leafstalk infection spreads down into the node, and where diseased the cane dries out and may crack (fig. 10).

TREATMENT

Prune out and burn old canes as soon as the berries are picked.

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[8] Caused by *Sphaerotheca humuli* (DC.) Burr (?).
[9] Caused by *Mycosphaerella rubina* (Pk.) Jacz.

LEAF SPOT [10]

Leaves of red raspberries are frequently affected by the same fungus that causes leaf spot of dewberries. (See p. 27.)

BLUE STEM [11]

Blue stem is a fungous disease which only recently has come to be recognized as of great economic importance in the Eastern and Central States. It has been reported as particularly serious in the Puget Sound country. The black raspberry is especially susceptible.

SYMPTOMS

The parasite causes dwarfing and wilting of the new shoots, turions, and fruiting canes. Certain of the symptoms produced are somewhat like those shown by plants infected with streak and mosaic. (See pp. 3 and 6.) The fruit dries up instead of developing a pulp. The leaves become discolored and wilt. The old canes may become blue-black or streaked. The affected new shoots also quickly turn blue-black, the leaves wilting and turning brown or yellowish, their stalks turning dark brown and becoming shrunken. Infected roots show reddish brown discolorations.

The fungus invades practically all parts of the plant except perhaps the leaf blades, growing especially in the vessels. The indications are that the fungus ordinarily lives in the soil, gaining entrance to the plant through wounds in the crown or roots.

TREATMENT

Plant healthy nursery stock. Dig and remove from the field wilted or dead plants. Two or three years should elapse before a field is replanted to raspberries. Avoid land previously planted to tomatoes, potatoes, or eggplant.

RASPBERRY FRUIT ROTS

Large quantities of raspberries are grown for the local markets, so that except where they are shipped long distances refrigeration is deemed impracticable. Any delay beyond a few hours which increases the time intervening between picking and sale to the consumer affords an opportunity for the development of fruit rots and molds. Wherever berries are bruised in picking or packing and when rotten, moldy, or overripe berries are shipped, the decay is sure to spread to the sound ones before they can be sold.

Practically the same molds and other fruit-rot fungi affect both raspberries and blackberries. A further discussion of this subject will be found under "Dewberry fruit rots" (p. 29).

GENERAL CONTROL MEASURES FOR RASPBERRY DISEASES

Certain measures of sanitation are helpful in the control of the various diseases of raspberries.

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[10] Caused by *Mycosphaerella rubi* E. W. Roark.
[11] Caused by *Verticillium alboatrum* Reinke and Berth.

Rotate crops. After destroying an old raspberry field, allow at least three or four years to elapse before replanting it to berries. Grow corn or other cultivated crops, grass, and legumes.

Procure clean nursery stock. Set the plants while dormant, and with blackcap varieties remove the attached stubs of old canes.

Destroy wild brambles in the vicinity of a plantation.

Practice clean cultivation so as to insure a good circulation of air among the canes. A heavy growth of weeds promotes a moist condition around the canes, which is favorable to the production of fungous spores and the infection of healthy plants.

Remove old canes immediately after the close of the picking season, cutting them as close to the ground as possible. At the same time dig out all dead or badly diseased plants.

Remove prunings from the field and burn them.

Spraying, roguing, and other specific control measures are discussed under the various diseases.

DISEASES OF BLACKBERRIES AND DEWBERRIES

ANTHRACNOSE OF BLACKBERRIES

The same fungus that causes anthracnose[12] of raspberry plants (see p. 11) also attacks those of the blackberry and dewberry. Some years the damage to dewberries in North Carolina may be as high as 50 per cent.

SYMPTOMS ON THE CANES

A few days after the fungus begins to invade the living bark of young canes there appear purplish spots half as large as a pinhead. These spots increase in size, turning light gray at the center, and the margin becomes purple-brown. The lesions may run together and become elongated and irregular in outline. The diseased tissue extends down into the bark, partly girdling the cane and interrupting the flow of sap. As the cane dries out it may become cracked. The scabby rusty brown spots will also appear on the green flower parts and fruitstalks.

SYMPTOMS ON THE LEAVES

Anthracnose does not usually cause much damage to blackberry leaves. It has been reported in the State of Washington that the leaves of the Snyder are very susceptible. The spots are at first very small, but by running together large whitish dead areas are formed between the veins.

ON THE FRUIT

The berries of most varieties of blackberries are fairly resistant, but the fruit of the Lawton is reported to be seriously affected in the Puget Sound region. Affected berries are undersized and deformed. Fruit seldom matures properly when the fruitstalks show a number of lesions. (See figs. 12 and 19 *A*, pp. 21 and 29, for anthracnose on dewberries.)

[12] Caused by *Plectodiscella veneta* (Speg.) Burk.

SUSCEPTIBLE VARIETIES

The Lawton (on fruit), Snyder, Kittatinny, Himalaya (on fruit), and Logan [a] blackberries and the Lucretia dewberry have been found to be among those particularly susceptible to anthracnose. Different varieties may vary as to their susceptibility in different localities. The Lucretia dewberry wherever grown is usually subject to this disease. In North Carolina all parts of the plant are attacked, in some cases a large loss being due to the scabbing of the berries. In the State of Washington, however, it is reported that the fruit of this variety is seldom attacked, whereas that of the Lawton is very susceptible to injury. The Evergreen (*Black Diamond*) is fairly resistant.

FIG. 11.—Anthracnose on Lucretia dewberry vines

ANTHRACNOSE OF DEWBERRIES

SYMPTOMS ON THE VINES

It is now a common practice in North Carolina, Georgia, and other Southern States to cut out all vines, both young and old, soon after the fruit is picked, so that in August one finds only newly grown vines. It is on the upper side of these young vines that the small purple spots caused by the anthracnose fungus first appear. They increase in size steadily, their centers turning gray, leaving a purple border. The fungus lives over winter in the spots, so that by the time the fruit is being formed the vines are frequently so nearly girdled as to cause their death before the fruit ripens (fig. 11).

The young fruit branches, peduncles, and green flower parts of the berry are often badly infected, further cutting off the food supply from the ripening fruit. Rusty brown or scabby spots on these fruiting branches are very likely to have been caused by anthracnose.

[a] Logan blackberry (instead of Loganberry) is the name approved by the Committee on Fruit Variety Nomenclature of the American Pomological Society.

SYMPTOMS ON THE LEAVES

The very light ashy-gray spots on leaves in fields where anthracnose is abundant on the vines will be found to be caused by the same organism. Damage to dewberry leaves is, however, of little consequence. Much of the spotting of leaves so often attributed to anthracnose is due to another fungus (see fig. 18, p. 28).

SYMPTOMS ON THE FRUIT

In North Carolina and Georgia much loss is due to the direct infection of the drupelets of the berries. If the berry is infected

FIG. 12.—Anthracnose on fruit of the Lucertia dewberry compared with two berries in the upper left-hand corner not diseased. (Photographed by F. A. Wolf.)

when it is still green it will soon show spots at the tips of the affected drupelets. These rough spots increase in size and extend deeper into the living tissue, thus preventing the normal ripening of the fruit, which will be small, dry, and worthless (fig. 12). In case of later attacks the drupelets turn a chocolate brown and develop an insipid pulp.

TREATMENT

In the more southern regions having a long growing season all the vines, both old and young, should be cut off close to the ground and burned after the crop is harvested. In northern regions only the old fruiting vines should be pruned away and burned. Wild

dewberries and blackberries along the borders of the dewberry fields should be mowed down and burned. If the diseased vines are then disposed of, anthracnose may be held in check fairly well in some sections. The application of 4–4–50 Bordeaux mixture has proved highly satisfactory in certain sections of the South.

In northern regions only the fruiting vines should be cut out and burned after harvest. Should anthracnose still prevail, three applications of Bordeaux mixture should be made, beginning with No. 2, the dormant spray, in the spring.

FIG. 13.—Crown gall on blackberry canes

Spray schedule for North Carolina and other Southern States

(1) Bordeaux mixture (4–4–50) when the new vines are a foot or two long, sometime in August.

(2) Bordeaux mixture (4–4–50) with a calcium-caseinate sticker, 1 pound to 100 gallons, or lime-sulphur (1 to 10) as a delayed dormant spray in the spring immediately after the vines have been tied up.

(3) Bordeaux mixture (4–4–50) just before the blossoms open; may be omitted if canes show no spotting.

(4) Bordeaux mixture (4–4–50) after blossoms have fallen and young berries are well set.

This last application of spray is very effective in preventing the occurrence of anthracnose on the fruit. Should this application be delayed too long and should there be no rain from the time of the application until after the berries are picked, they are liable to show stain to such an extent as to prevent their sale.

CROWN GALL

See crown gall of raspberries, page 13 and Figure 13.

DOUBLE-BLOSSOM (DOUBLE-BLOOM) [13]

Double-blossom is a fungous disease which seriously affects certain varieties of blackberries and dewberries. It is much more common in the Southern States, not being of much economic importance in

[13] Caused by *Fusarium rubi* Wint.

the more northern States. Raspberries are not know to be attacked by this fungous disease.

SYMPTOMS

The axillary buds on new canes or vines become infected in early summer, but show no striking signs of infection until the following spring. Short leafy sprouts then grow out at the infected nodes, forming little witches'-brooms (figs. 14 and 15). The flower buds are somewhat larger and coarser than usual; the petals are much wrinkled and twisted as they unfold, and they are frequently pinkish in color; the pistils are large and long. Several of these witches'-brooms may be found on one cane. No berries are produced at these points, although uninfected parts of the same cane may bear some poor fruit.

Double-blossom is being frequently reported on the Florida Marvel variety, but the disease is not always manifested by witches'-brooms. The diseased blossoms are, however, characteristically curled and highly colored. The sterility of certain flowers, due to insects which prevent the development of pollen and therefore the setting of fruit, should not be confused with double-blossom effects.

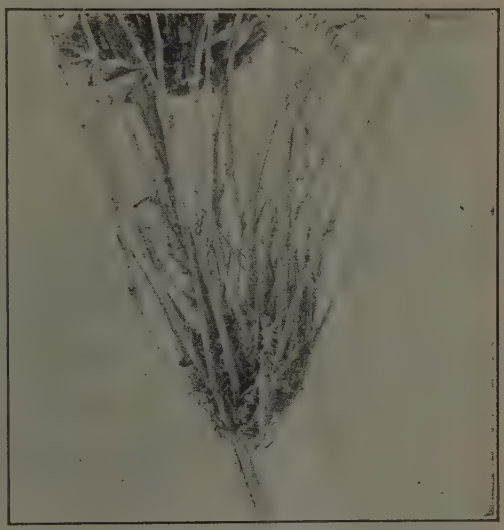

FIG. 14.—Double-blossom witches'-broom on the Jumbo blackberry

TREATMENT

The only known method for controlling this disease on blackberries is to remove the double-blossom clusters from the canes by hand picking before the blossoms open. As the double-blossoms contain vast numbers of the fungous spores, they should be carefully gathered and burned. Wild blackberries and dewberries in the vicinity should be cut out and burned as far as practicable.

SPECIAL TREATMENT

In the Southern States, Delaware and southward, where the growing season is long, complete control of double-blossom on Lucretia dewberries is obtained by cutting off all vines, both new and old, close to the ground after the fruit is picked. The disease does not affect the new growth that comes up after this operation. In north-

ern regions where sufficient new growth can not be obtained in case all the vines should be cut out after harvest, only the old vines should be cut and burned. It will also be necessary to hand pick and burn the double-blossoms as they appear.

ORANGE RUST[14]

SYMPTOMS

Orange rust is a fungous disease which makes its appearance in the spring soon after the leaves unfold and continues to show on leaves, especially new canes, for four or five weeks. The infected turions, or basal shoots, are rather spindling and clustered. Their leaves are yellowish green and in some cases are covered with minute reddish bodies which represent the first stages of the rust fungus.

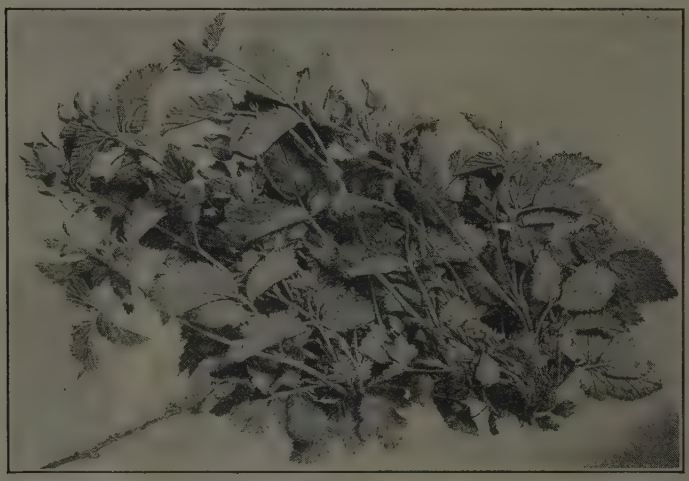

FIG. 15.—Double-blossom on the Lucertia dewberry

In two or three weeks the under side of the leaves will be covered with blisterlike orange-colored pustules filled with waxy spores. (See fig. 9.) When dry the spores may fall out and cover the leaves below. Later the tips of the infected young canes seem to grow away from the fungus and recover, so that late in July or August even in the Northern States no orange rust will be found in the field. The infected canes, however, never reach the size of normal canes and bear no fruit the following year.

HABIT OF GROWTH

The fungus grows down into the crown and out into the roots, so that the new shoots which spring up each year from infected parts will also be diseased. At the time the spores are shed the new shoots

[14] Caused by *Gymnoconia interstitialis* (Schl.) Lagh. form *Cæoma nitens* Schw. (See also orange rust on black raspberries.)

breaking through the ground are in just the right condition to be infected. It is usually through the young shoots that new plants are systemically or permanently infected by orange-rust spores.

Occasionally a new shoot from an old crown is attacked by the fungus. The canes from the rest of the hill will continue to remain uninfected and will bear fruit. The rust may thus live several years in such a plant before all the canes will show rust. A new root shoot infected one spring will grow up into what looks like a normal cane, which will blossom the next year, only leaves at the base showing rust. The following year, however, most of the canes in this hill will be found to be dwarfed and without blossoms (fig. 16).

THE LONG-CYCLE RUST [15]

Another form of orange rust, the one found on black raspberries, also attacks blackberries. For all practical purposes the symptoms and methods of control are the same as for the short-cycle form, already described.

SUSCEPTIBILITY

Probably none of our cultivated varieties is actually immune to orange rust. The Snyder, Evergreen (*Black Diamond*), and Eldorado, though very resistant, can be infected. Many wild dewberries are very susceptible, yet the Lucretia is resistant. The Lawton blackberry is also resistant.

TREATMENT

Plant rust-free nursery stock. If orange rust appears on a blackberry during the spring or summer it is set out, it means that the stock was infected when planted. Cuttings for new plants should not be made from roots or canes of any hill which has shown this rust.

Plants showing orange rust should be pulled up by the roots. This should be done before the spores are being shed.

If new plantings are carefully inspected and all rusted plants rogued the grower will have no difficulty in later keeping his fields free from orange rust. Should rust appear on blackberry leaves in August or September it is not orange rust, and the plants should not be destroyed.

CANE RUST [16]

Considerable damage to fruiting canes is often caused by another rust fungus, which is frequently mistaken for orange rust. The bark of badly infected canes splits open, showing the golden-yellow or lemon-colored spores. These canes dry out to such an extent as to prevent proper ripening of the fruit. The pustules of the orange rust never break out on the old bark of fruiting canes. The cane-rust does, however, attack the leaves of the turions, or young canes, later in the summer. The pustules also appear in the spring on the new leaves of old canes and on the canes where it has overwintered. The leaf infections may be so severe as to have a serious effect on next year's fruit crop. At the close of the life cycle of the rust the

[15] Caused by *Gymnoconia interstitialis* (Schl.) Lagh.
[16] Caused by *Kuehneola uredinis* (Lk.) Arth.

FIG. 16.—Orange rust on blackberry, showing also witches'-broom the second year after infection

pustules on the older leaves are often snow white (fig. 17.) Infected leaves are not dwarfed by cane rust. The distinguishing characters of cane rust and orange rust are summed up as follows:

ORANGE RUST	CANE RUST
(1) Rust pustules break out in spring.	(1) Rust pustules from spring throughout the summer.
(2) Pustules are orange colored, spores waxy.	(2) Pustules golden or lemon yellow, spores rather dry (in the more mature stages snow white).
(3) Rust pustules only on leaves.	(3) Rust pustules on canes and leaves.
(4) Fungus invading roots, canes, and leaves.	(4) Fungus local in canes and leaves.
(5) Dwarfs canes and leaves: causes much sprouting from root and crown; prevents blossoming.	(5) Causes cracking and drying of canes and spotting and drying of leaves. Does not prevent blossoming.
(6) Spreads to new plants through growth from roots and crown into new shoots, and by spores to young shoots in the spring.	(6) Spreads entirely by spores. Primary infections in spring, secondary throughout the summer.

TREATMENT

Since the crown and roots of a plant infected with cane rust do not carry the fungus, they should not be dug up, as in the case of the orange rust. Destruction by burning of badly infected canes is advisable and would help to prevent the spread of the disease. No other practicable method of control has been worked out.

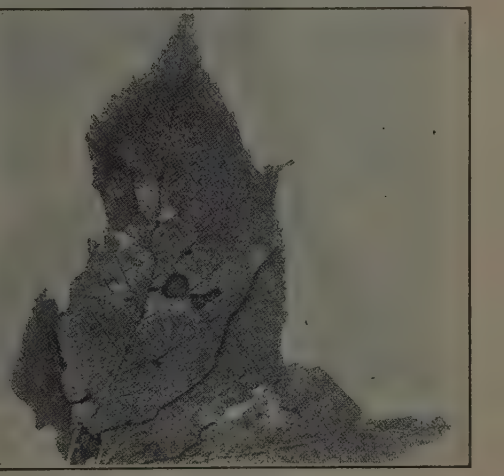

FIG. 17.—Late stage of cane rust on the under surface of blackberry leaves. (After C. R. Orton)

LEAF SPOT [17]

Leaves of blackberries and dewberries are frequently badly spotted by a fungus which is often confused with anthracnose (fig. 18, *B*). The spots are bordered with a purple margin and are more circular in outline (fig. 18, *A*). Small black fungous fruiting bodies can be seen on the gray central portion. This spot disease is seldom serious and will be kept in check where the plants are sprayed for anthracnose.

LEAF BLIGHT [18]

The growing of dewberries in certain Southern States where the rainfall is rather high during the dewberry season has been attended

[17] Caused by *Mycosphaerella rubi* E. W. Roark.
[18] Caused by *Cercospora rubi* Sacc.

with losses due to a leaf-blight fungus not commonly thought to be of economic importance. This fungus usually causes only local spotting of leaves. Warm rainy weather so favors the disease on the Lucretia dewberry in the South that large areas on the leaves become affected and appear brown as though scorched.

TREATMENT

As anthracnose will no doubt be present wherever leaf blight is a serious problem, no special treatment other than spraying as scheduled for anthracnose (p. 22) is recommended.

FIG. 18.—Leaf spot (*A*) and anthracnose (*B*) on leaves of the Lucretia dewberry. (Photographed by F. A. Wolf)

DISEASES OF THE LOGAN BLACKBERRY

The cultivation of Logan blackberries is a rather recent undertaking, restricted almost entirely to the west coast. Anthracnose, crown gall, orange rust, and other fungous diseases, as well as certain types of mosaic, are reported on this variety. It may be that certain modifications in the methods recommended for the control of these diseases on blackberries and raspberries will be found necessary, on account of the habits of growth of this variety and the cultural conditions and climatic differences encountered.

DEWBERRY FRUIT ROTS

On account of the time which intervenes between the picking of the berries and their purchase by the consumer, further loss is liable to occur through rotting of fruit by certain fungi in transit.

ANTHRACNOSE

Berries that have been directly infected by anthracnose (figs. 12 and 20, *H*) should be discarded, even though the disease appears too late to prevent the development of some pulp. These brown scabby berries arrive at the market in bad condition and consequently lower prices (fig. 20, *A*). In Figure 19 two quarts of dewberries from the same car are shown. The berries in one box had been carefully picked by the grower; the others had become infected with anthracnose and bruised by hail some time before they were picked, but they were a fair sample of those shipped on this date from this

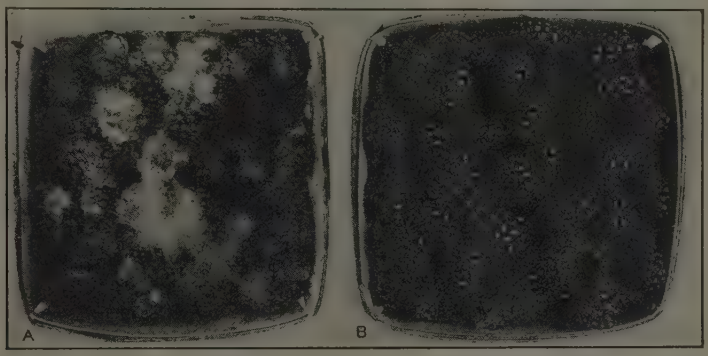

FIG. 19.—Spoilage of dewberries in transit: *A*, berries from a field having anthracnose and some hail injury; *B*, an honest pack from another field. The same conditions in transit existed in both cases

field. After five days in transit and over 24 hours without refrigeration, the difference seen should be expected.

BLACK ROT [19]

Where overripe berries are included in the pack they are liable to develop black rot in transit (fig. 20, *C*). The fungus producing this rot is closely related to the one producing black rot of grape, but unlike the latter it does not attack green fruit.

MOLDS

If the berries are bruised in picking or are jammed by crate covers or separators, or where overripe and otherwise defective berries are included in the pack, various kinds of molds appear as soon as the temperature is allowed to rise much above 50° F. (Fig. 20, *A*, *B*, *D*.) Such berries affect the sale price in the wholesale market, although the percentage of such moldy berries may not be great.

[19] Caused by *Phyllostictina carpogena* Shear.

PIEBALD BERRIES

During certain years numbers of berries may be affected with a peculiar malady, the cause of which is yet unknown. From one to several carpels (drupelets) of a berry fail to develop color and have an unpleasant flavor. The skin of such carpels is so thin that rot fungi, such as blue mold, bread mold, and Patellina soon attack them and then spread to sound parts. Figure 20, *F*, shows such a

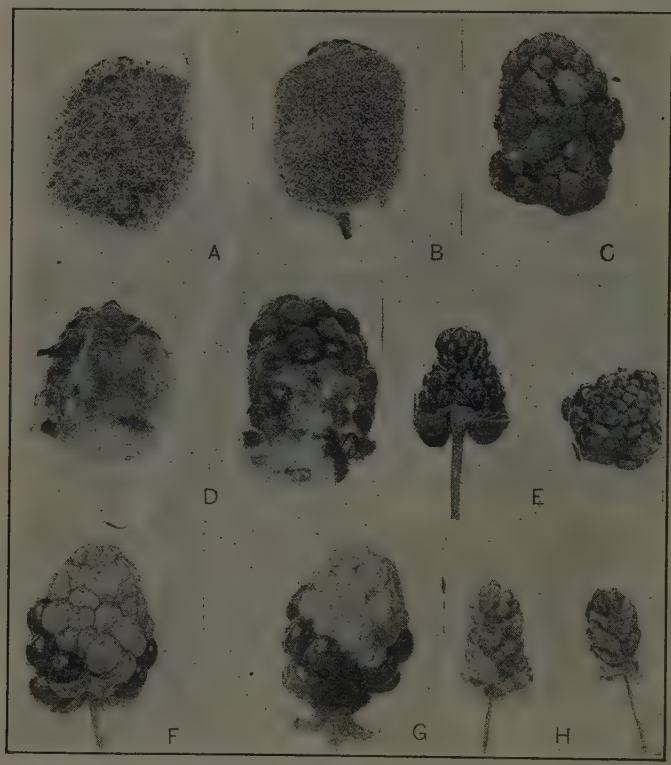

FIG. 20.—Fruit rots of Lucretia dewberry: *A*, Rhizopus (leak); *B*, gray mold; *C*, black rot; *D*, Alternaria mold; *E*, nubbins; *F*, piebald; *G*, the same berry as *F*, showing decay of white carpels two days later; *H*, anthracnose

berry, and Figure 20, *G*, the same berry two days later, with the white carpels covered with mold and rotting. A somewhat similar malady is reported on blackberries grown along the Pacific coast. The affected drupelets remain red instead of turning white. It has been recently discovered that this redberry is caused by a certain species of mite [20].

[20] Essig, E. O. The blackberry mite, the cause of redberry disease of the Himalaya blackberry, and its control. Calif. Agr. Exp. Sta. Bul. 399, 10 p., illus. 1925.

SUMMARY OF CONTROL OF FRUIT ROTS

Prevent anthracnose of fruit by spraying after the blossoms fall (see p. 22). Pick the berries as early in the day as possible; pull them without bruising. Discard rotten, overripe, sunburned, and imperfect berries. Set the carrier in the shade while filling the box. Avoid bruising the berries with crate separators or covers. Let them stand in a cool shady place and keep them covered with canvas while hauling to market. If shipped under refrigeration, get the berries in the car as soon as possible after they are picked. Do not hold berries over night without refrigeration.

MOSAIC AND OTHER RELATED DISEASES

Virus diseases frequently attack blackberries, causing either mottling or deforming and dwarfing of the leaves, sometimes accompanied by stunting of the plants. Mosaic, leaf curl, and streak have been found, the last two causing severe stunting of the plants and entire lack of marketable fruit; leaf curl, however, is very rare. Infection has been seen on wild blackberries of several species, especially south of the fortieth parallel of latitude. Cultivated varieties do not seem to be so much affected, although several of them are susceptible. The Eldorado, the most important variety in many sections, appears relatively free.

These diseases of blackberries are transmitted to suckers and root cuttings of affected plants and are carried from one plant to another by aphids.

METHODS OF CONTROL

Procure healthy stock for planting, grow resistant varieties when practicable, and inspect and destroy diseased plants. Effective control by roguing is difficult because of the strong tendency of cut roots to send up shoots. This makes it necessary to attempt complete removal of diseased roots and to watch the vacant places to catch any diseased suckers which may later spring from overlooked bits of root. All growth, above and below ground, within 3 feet of each plant showing disease symptoms should be removed.

SUGGESTIONS FOR PREPARING BORDEAUX MIXTURE

Bordeaux mixture may be prepared in small quantities as follows:

(1) Place 4 pounds of copper sulphate (bluestone) in a sack and dip the sack in a barrel containing 25 gallons of water. Metal tubs or pails are corroded by bluestone. Hot water hastens the dissolving of bluestone.

(2) Slake 4 pounds of good stone lime in water and when slaking is over add water to make 25 gallons. If some of the lime is air slaked, it is necessary to use more than 4 pounds. If hydrated lime is used, 6 instead of 4 pounds is recommended.

(3) Pour these two solutions together into the spray tank. Since large particles clog the nozzles of the sprayer, the solution should be strained, preferably through a wire strainer with fine meshes. Bordeaux mixture should be applied as soon as possible after mixing together the bluestone and lime solutions. The spray will be more effective if calcium caseinate, 1 pound to 100 gallons, is added.

When large quantities of Bordeaux mixture are required, a stock solution may be made up as follows:

(1) Dissolve 25 pounds of bluestone in 25 gallons of water, as directed in paragraph 1 above.

(2) Slake 25 pounds of stone lime and add water to make 25 gallons.

(3) To prepare 50 gallons of Bordeaux mixture from the stock solution thoroughly stir both stock solutions. Take 4 gallons of the bluestone solution and make this up to 25 gallons. Take 4 gallons of the lime solution and make this up to 25 gallons. Pour the two solutions together through a strainer into the spray barrel or tank. Unless the stock solutions are diluted before they are poured into the spray barrel, it will be necessary to stir the mixture thoroughly as the stock solutions are being poured in. From 20 to 25 pounds of bluestone should be sufficient for an acre.

The sprayer should be mounted on a drag or sled and provided with two leads of pressure hose 25 feet long, a spray rod about 2 or 3 feet long, and angle nozzles. Outfits with pressure chambers are best. One barrel sprayer will take care of 25 acres. Several men together may own an outfit. It will last for several years if given care, which includes thorough washing out of the sprayer after spraying is finished and the oiling of metal parts.

Spraying must be done properly and at the right time. The spray should be delivered from the nozzles as a fine mist, not as a rain. It will then cover and penetrate well. The plants should not be drenched; this wastes material.

LIME-SULPHUR SOLUTION

Concentrated lime-sulphur solution (33° Baumé) may be obtained made up ready for dilution from dealers in spray supplies. This solution may also be made on the farm. (See Farmers' Bulletin No. 908, entitled "Information for Fruit Growers about Insecticides, Spraying Apparatus, and Important Insect Pests," pages 18 to 28.) Essentially the same material may be obtained in dry form, but unfortunately in the case of some of these dry mixtures it is often necessary to use nearly twice as much as is recommended by the manufacturers.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

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